Final Report to Department of Pesticide Regulation
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Project Title: Management of riparian woodlands for control of Pierce's disease in coastal California

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Summary:

This is a complex, multi-year project to develop and assess a new method of managing Pierce's disease (PD) of grapevines by altering the plant habitats of the principal insect vector of PD, the blue-green sharpshooter (BGSS). Our goal is to devise methods to reduce populations of BGSS by replacing plants such as wild grape, blackberry, and others used by BGSS for breeding with plants that are not favored by the BGSS for reproduction or feeding. We also are testing buffer strip plantings of redwood and Douglas fir between vineyards and riparian woodlands as a barrier to reduce the influx of BGSS into vineyards during spring. Our second goal is to reduce the percentage of BGSSs that are infective with the Pierce's disease bacterium (*Xylella fastidiosa*) by replacing plants that support the multiplication, within-plant movements, and year-round survival of *X. fastidiosa* with plants that do not. Over the past year (1996-97), we observed extremely encouraging first results with the riparian removal and replanting treatment. Sticky trap catches of BGSS were reduced over 97% in the treatment in which vegetation was removed and replanted. There were no major differences between undisturbed controls and buffer strip plantings, but the Douglas fir and redwood replants that are to make up the buffer were very small (< 1 meter). Baseline data was recorded from 2 additional sites, one along the Napa ?River near Yountville, and another along Mayacamas Creek in Sonoma County. Vegetation removal was started at the Napa River site and should commence this spring in the Mayacamas Creek site.

Results and Discussion: (by objective)

Objective 1: Manipulate the structure and composition of forest plants bordering a typical intermittent-flow coastal stream near commercial vineyards by selective plant removal and control and by planting of tree and shrub species to reduce breeding of the blue-green sharpshooter and its dispersal to adjacent vineyards.

The second replication of the removal and replacement treatment is along the Napa River south of its confluence with Conn Creek. An additional replicate along Mayacamas Creek in Sonoma County near Geyserville will be added as soon as we receive the anticipated approval by the California Department of Fish and Game. We anticipate that we will continue to confront unanticipated problems that require solutions as we progress through the experiment. Weather problems, chiefly the amount and timing of rainfall, made establishing transplanted hardwoods difficult or impossible, depending on whether fall or winter planting was attempted. We will explore direct seeding as an alternative to bare root transplants. Details of plant removal, planting and a brief discussion of problems are in Appendix 3.

Objective 2: Monitor the effects of riparian vegetation management on population density, dispersal and infectivity with *Xylella fastidiosa* of the blue-green sharpshooter vector of Pierce's disease.

A. Monitoring of the blue-green sharpshooter (BGSS). The 97+% reduction in BGSS activity as measured by yellow sticky trap catches in comparison to the undisturbed controls at the first experimental site along Conn Creek exceeded our expectations (see Appendix 1). As replanted

hardwoods continue to grow, we expect this difference in BGSS activity to diminish somewhat. Future studies will have to include some research on effects of the treatments on wildlife and other biota in riparian woodlands and associated streams. A proposal has now been prepared by Dr. Donald Dahlsten, U. C. Berkeley. One such study of the effects on aquatic invertebrates and water quality headed by Dr. Vincent Resh, U. C. Berkeley is underway. Studies of the impacts of vegetation changes on wildlife will be proposed to AVF and other agencies in 1997 by U. C. Berkeley researchers.

B. Testing individual BGSS (or groups) for transmission to test grapevines in lab. Adult BGSS were collected from riparian vegetation in August-September, 1996. The insects were placed the same day individually or in groups of 5 or 10 on grape test plants in the lab for at least 4 days. A total of about 100 BGSS were tested from each location. We were unable to find any BGSS from the plot in which breeding plants had been removed. We diagnosed the test plants for Pierce's disease visually after three months and then attempts made to culture the bacteria from any questionable or symptomless plants. Over the first 2 years of monitoring BGSS in a Napa Valley site along Conn Creek, testing of BGSS estimated rates of infective (transmitting) BGSS collected in August-September at about **5% in 1995 and 50% in 1996**. It is highly improbable that vegetation management to date caused this large increase in infectivity because there were few changes in the plant populations or population densities of BGSS in the undisturbed plots from which the insects were collected. Whether or not vegetation management can lower infectivity rates of BGSS may be difficult or impossible to evaluate with this degree of annual variability in infectivity rates. Additionally, vegetation management procedures may so effectively reduce numbers of BGSS that too few adult BGSS can be collected from treatment areas to compare differences among treatments.

Last year we confirmed that periwinkle ground cover (*Vinca major*), an escaped ornamental that is common along many riparian habitats, is a systemic host of *X. fastidiosa*. This is an attractive plant for BGSS adults in late winter through early spring, so may especially important to eliminate near vineyards because it serves to attract and concentrate overwintering BGSS adults just before the critical period for infection of grapes by *X. fastidiosa*. Because many BGSS probably tend to remain in the same general area overwinter, reducing wild grape populations from riparian vegetation and either eliminating BGSS in commercial vineyards or removing diseased grapevines and other systemic hosts of *X. fastidiosa* may substantially reduce infectivity rates in BGSS. Simultaneously reducing populations of BGSS and highly efficient plant hosts of *X. fastidiosa* may be synergistic in reducing infection rates of BGSS.

C. Monitoring the establishment and growth of planted trees and shrubs. See Appendix 3 for details.

Outside presentations of research:

Research progress on Pierce's disease research over the past year was presented by A. H. Purcell and discussed at the University's Grape IPM Conference at the Kearny Agricultural Center, November 12, 1996. Purcell also gave a sponsored presentation on Pierce's disease at the South Coast Wine Grape Day in Temecula, CA on Jan,. 10 and at Wine Tech/Grape Tech in Sacramento on Jan. 29, 1997. McBride gave a talk on "Vegetation Management for Pierce's Disease" to range managers at Hopland Field Station on Feb. 26, 1997. We are planning training workshops on Pierce's Disease for Sonoma County in three phases of one day each to provide growers first hand experience necessary to understanding disease prevention strategies and adapting them to their own situations. These workshops will build on experience gained from the last 2 years' workshops. Rhonda Smith, UC Cooperative Extension Farm Advisor for Viticulture, is arranging these meetings. Cooperative Extension IPM Specialist Lucia Varela is updating a syllabus and will give presentations for these the workshops. Purcell, McBride, and Kirkpatrick will participate. U. C.

Cooperative Extension in Napa County (Ed Weber, Viticultural Farm Advisor) will schedule training sessions in Napa County.

Updates of research were presented to the Napa Valley Pierce's Disease Task Force at their quarterly meetings in 1995-96 and to the Napa Valley Viticultural Technical Group on February 7. Presentations on Pierce's disease research updates are scheduled for the Sonoma County Grape Day on February 29 (arranged by Rhonda Smith, Sonoma County Farm Advisor), and with Mendocino growers on March 1 (arranged by Glenn McGourty, Mendocino County Farm Advisor).

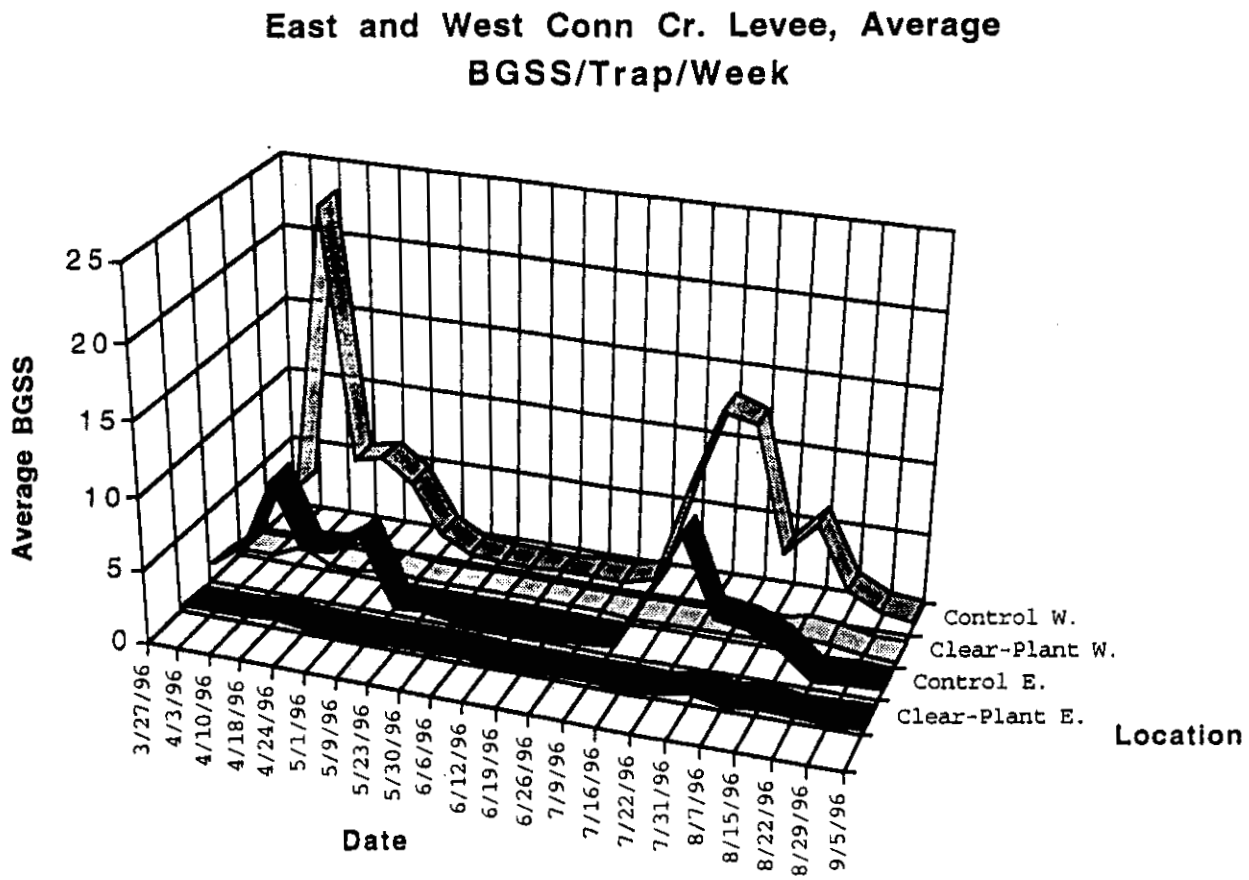
APPENDIX 1

Summary of yellow sticky trap catches of the blue-green sharpshooter in 3 sites in 1996.

Riparian Zone	Treatment		Total BGSS Trapped in 1996 Number March-June	July-Sept.
Conn Creek	East Levee	Remove-Replant	1	3
	Gamble	Control	66	63
		Control vineyard	22	28
		Buffer	114	132
		Buffer vineyard	63	131
	West Levee	Remove-Replant	5	5
	Gamble	Control	244	183
		Control vineyard	46	108
		Buffer	144	198
		Buffer vineyard	31	113
	East Levee	Buffer	3	10
	Krug	Control	53	148
		Control vineyard	31	27
	West Levee	Buffer	5	93
	Krug	Buffer vineyard	0	65
		Control	15	43
		Control vineyard	0	72
Napa River				
	East Levee	North Control	57	23
	Silverado	South Cleared	79	22
		South vineyard	13	14
	West Levee	North Control	108	162
	Beringer -Miller	North vineyard	278	223
		South Cleared	42	17
		South vineyard	0	8
Mayacamas Cr.			May-June	July-Sept.
	Simi	South Levee	47	418
		South vineyard	55	390
		North Levee	15	9

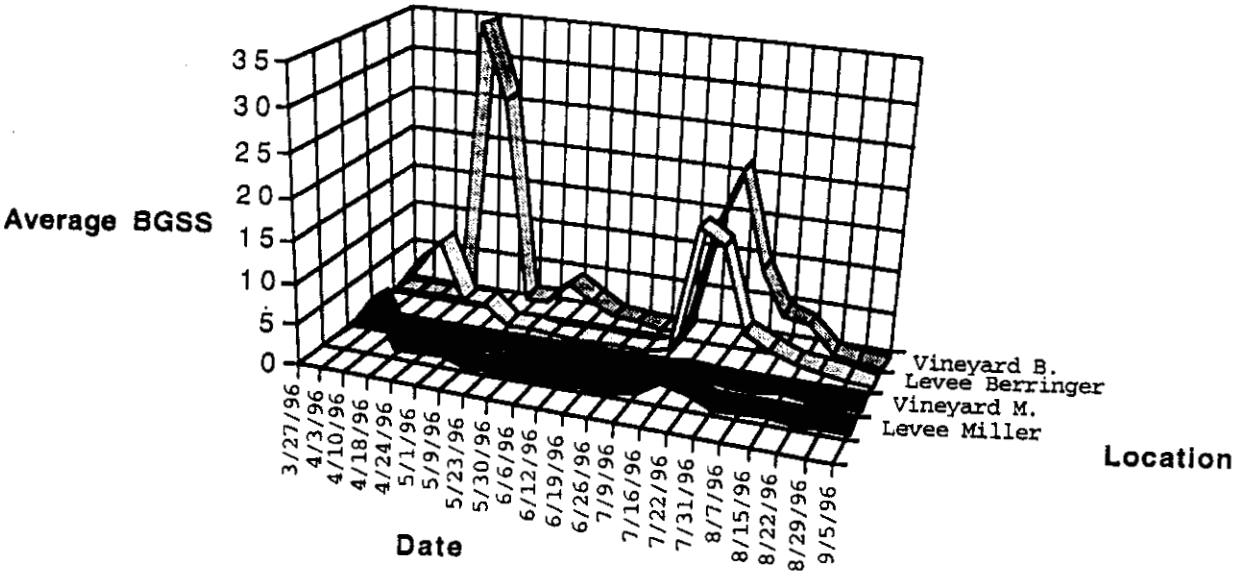
APPENDIX 2A

Sticky trap catches of blue-green sharpshooter (BGSS) at northern Conn Creek site, 1996. Data are presented for both the east (E) and west (W) sides of the creek. Note symmetries of catches in the cleared and replanted plot ("clear") and the undisturbed ("control") plots and the large differences in total catch between the treatment and control plots. Not all plots had adjacent vineyard plots (vineyard data not shown here). See also Table in Appendix 2 for summaries of total trap catches.

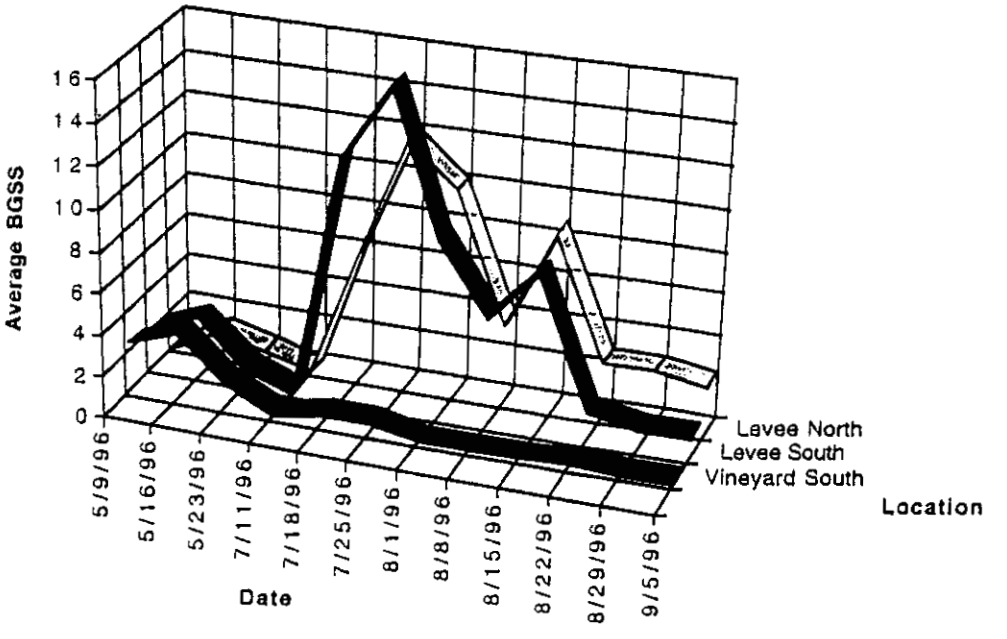


APPENDIX 2 B and C

B. Sticky trap catches of blue-green sharpshooter (BGSS) at Napa River site, 1996. Data are presented as average trap catch per week per trap for traps in riparian vegetation and in adjacent vineyards. See also Table in Appendix 1 for summaries of total trap catches.



C. Sticky trap catches of blue-green sharpshooter (BGSS) at Mayacamas Creek site, 1996. Data are presented as average trap catch per week per trap for traps in riparian vegetation and in adjacent vineyard on south side. The vineyard on north side is being replanted and will be monitored next year). Note approximate symmetry of catches on both sides of creek. See Table in Appendix 2 for summaries of total trap catches.



APPENDIX 3 **Descriptions of plant removal and planting**

Plant removal and replacement

Conn Creek. The site has been weeded by hand, supplemented with spot control of resprouts with glyphosate . Weed control on the site beginning in mid-winter is important to insure continued vigorous growth of the seedlings and insure eventual reduction in herbicide applications. Weed free spaces at this time would allow the testing of direct seeding techniques that may be useful to supplement planted seedlings or to use on similar riparian corridors. Unfortunately a third year of continued heavy rainfall and flooding on the Napa River and Conn Creek during the 96-97 winter precluded access and desired weed control. Presumably all seed test spots that were hand sown in December 1996 were washed away or buried by sand. The planted seedlings are now in the process of being hand weeded since the warm winter has led to some new shoot growth precluding any herbicide use until all the seedlings are visible. Other than debris now being removed after deposition in seedling tops there does not appear to be any significant damage to the seedlings but their actual health will not be known until early spring. The root systems may have undetected root infections from soggy soils and unseasonably warm soil temperatures. Also the early shoot growth because of the warm winter may prove more deleterious if there is a hard frost. Any mortality will be replaced in 1998 with seedlings that will include white alder, box elder, and Fremont Cottonwood.

Conifer buffers.

In 1996 we planted Douglas fir seedlings in a 12 to 18 foot wide strip adjacent to the levee on the 700 foot long section that extended north from Rector Creek. About one quarter of the conifer transplants on both sides of Conn Creek died as a result of compacted soil and flooding of planted holes. We are not certain how much the conifer roots can exit the planting holes except in less compacted soil next to the woodland, where drought stress may become severe. We planted a total of 525 Douglas firs in three rows on 4X4 foot spacing on each side of the creek. We will continue to monitor their survival and growth.

The 1997 flood caused the same havoc on the conifers with debris and downed trees and branches remaining to be cleared along with the weeds. The warm winter and soggy soils for a protracted period may have severely harmed the Douglas fir since their roots are actively elongating at such soil temperatures and do not tolerate aerobic soil condition unlike the redwood that is adapted to periodic flooding.

Descriptions of new experimental units

Napa River Vegetation Management:

The Napa River section bounded by the Silvered and Beringer-Miller vineyards has had a history of vineyards lost to Pierce's disease. Our original plan was to have a season of trapping and sweep netting prior to any vegetation management but the widespread concern of not having an experimental unit along the major continuos flow riparian zone led to an early acceptance of our research proposal by the regulatory agencies involved. Consequently the late season BGSS population sampling was compromised by vegetation clearing along the southern 2000 foot section bounded by the Severed and Miller vineyards. The Beringer and north section of Silverado will serve as the control unit during subsequent BGSS and bacteria population studies.

The vegetation during August 1996 was mechanically removed with the chipped material spread on the future planting sites. Generally the same vegetation was removed as along Conn Creek from the levee edges down to the seasonal high water level except willow thickets were more common than Himalayan blackberry and red willow. The trees were in the range of 6-10 inches DBH and 25-30 foot tall and reduced the population of trees susceptible to being uprooted by wind and flood. Several large elderberry clumps were also removed along with the wild grape overgrowing desirable trees. Some older trees were left that are in poor health from broken branches and obvious bole rot that should have been cleared. The expense to the vineyard and the perception by regulators of trees tending to become snags as valuable for wildlife habitat overrode

any consideration of their weakened physiological state and root systems subject to erosion and the possible consequences during floods along the artifact of a leveed river. The abundance of native hardwoods left on the levee-primarily walnut and live oak-has resulted in several cleared areas ranging in size from 200 to 2500 square feet that will fully test the efficacy of filling gaps in narrow riparian zones and leaving old trees whose health may improve and or inhibit the growth of planted seedlings. One season of experience on Conn Creek indicates competitive effects of established trees on seedling survival or growth could be more severe on these steep levees where slope aspect affects incident sunlight.

The east levee has a deteriorating paved surface and more down slope rubble and the majority of the smaller planting site scattered over the 30 feet to the river. The west levee is topped by compacted soil and slopes to the river over a range of 40 to 60 feet with the large planting sites being the consequence of removing old, fallen red willows. In places another 10-15 feet of planting width can be added on the levee without interfering with the vineyard operations. Soil sampling will be needed to assess how best to replant the variable planting sites

Planting of native trees during the 1996-97 winter will be by fall 1996 collected seed that will also be used to grow bare-root nursery seedlings for follow up planting in 1997-98. The construction of the levees to be planted and their repair history has led to extensive areas where tree regeneration may be successful by planting seed that can grow roots within the soil filled interstices of the rubble down 8-14 inches to adequate soil. It has not yet been determined whether the few instances of oak or walnut saplings growing out of the surface ruble are of seed origin or sprouts from stumps covered by rubble. Regardless, pick and shovel will be used when the nursery grown seedlings are available to test on such sites. The introduction of shrub plantings will be governed by experience gained on Conn Creek interpolated with the behavior of the new tree plantings on this site, but it is assumed that seedlings will take 2-3 years longer to become established on this site. Unless soil pits reveal some surprises, there is no anticipation of any problem with establishing new trees greater than on Conn Creek. We will also test the feasibility of cuttings of white alder, box elder, and Fremont cottonwood as cuttings of willow are used in stream bank stabilization. All three are easily rooted but have a narrow time period of peak performance for rooting.

The 1997 flood along this section of the Napa River scoured the banks of both the control and treatment segments exposing many tree roots. The cleared section to the south did not suffer any levee break due to tree uprooting since the most susceptible were removed along with some downed trees that would have directed flood waters into the levee. The control section to the north had more levee damage related to toppled trees in conjunction with large gravel bar on the north end that caused severe erosion on the west levee. It is anticipated that the planting of seed in the cleared section will proceed in March 1997.

Maacama Creek Vegetation Management:

The Maacama Creek in Sonoma county drains the watershed to the east from Ingalls Bluff to Mt. St. Helena. It is a non-impounded stream that flows west through the Simi Vineyards, south and east of the Rt. 128 and Chalk Hill Rd. intersection, to a confluence with the Russian River. As most streams in northern California coastal valleys it has both an altered narrow riparian zone and flood plain due to past agricultural practices, road and bridge construction, wildfire control, and introduction of exotic vegetation that all interact during seasonal droughts and floods to change a potential landscape amenity into a liability for vineyard culture, the suburban polity, and historical or new wildlife populations.

This creek will differ from our experience on Conn Creek or the Napa River because it lacks the constructed levee system, gravel mining, or past history of extensive bulldozer stream bed weed control. It is similar because these altered coastal streams are a narrow corridor of native trees such as oaks, buckeye, and bay that covered the more extensive historical flood plain, now under cultivation or housing, intermixed with walnut, maple, alder, ash and box elder that in the past inhabited the stream banks. Red willows that are present have the growth habit common to non-impounded streams where even in drought years there is often a sufficient high flow to uproot

them insuring their continued resprouting in contrast to dammed streams where they can reach tree size. Interior to the hardwoods from the upper banks to the creek is an extensive undergrowth of exotic weeds as in the Napa Valley that eliminates any regeneration from seed of the native hardwoods resulting in the same pattern of unsustainable remnants of the historical vegetation or wildlife. Similarly the same narrowness of these riparian zones and lack of a dense tree canopy permit sufficient light to promote weed growth and the development of large BGSS and bacterial populations.

The study site is a 2200 foot long riparian corridor of Maacama Cr. that varies from 150 to 250 feet in width bordered on both sides by Simi Winery vineyards that we collected BGSS population data on during the 1996 growing season. We propose that this section of the creek be divided into equal treatment and control sections in the spring of 1997. One section beginning at the horse corral, on the south corridor will go east for 1100 feet and have no vegetation management or operations during the experiment other than population sampling for BGSS activity and plant infection. It will also serve as the basis for gathering comparative data such as the changes in types, performance, and behavior of both residual trees and wildlife on the vegetation management section that continues east for 1100 feet where the south vineyard ends. The north vineyard will have matching experimental units on the opposite stream side where a new vineyard planting replaces one recently lost to Pierce's disease. Vector and bacterial population sampling will begin again in the spring of 1997 and continue through the late summer when clearing of vegetation in the treatment section will commence. The clearing by mechanical tools followed by herbicides will take approximately two weeks depending on the labor source, usually some combination of youth conservation corps and vineyard workers depending on other demands on their time. Native trees will be grown from seed in a bare root nursery for planting in the late winter of 1997. Our experience is that by keeping these planted seedlings free from competitive growth for two to three years insures their survival and important initial root and shoot growth. Consequently, the introduction of native woody shrubs that outgrow native tree seedlings early in their life cycle will be delayed for two years as on the Napa Valley sites.

The Maacama Cr. watershed has had above normal rainfall the past three years and significant episodes of high flows that have damaged parts of the creek in the vineyard. The eastern 1100 section was chosen for clearing and re-planting because the most bank erosion and shifted gravel and sand deposits have occurred on this portion especially in 1996-97. The prior two years increased the size of a gravel bar and associated sand deposits and weakened trees at the eastern terminus of the treatment section that led to this years tree fall. Thus the high 96-97 flows were diverted into the north stream bank and eroded the bank. The future of this section appears to be a large swath of periwinkle, Himalayan blackberry, and mugwort bordered by a single line of trees adjacent to the vineyards. Extensive weed growth in the openings will increasingly promote its invasive growth under the existing trees as canopy shading decreases because soil moisture and nutrients become less available to the trees.

The first 600 feet of the treatment section is dominated on the south side by a gravel bar that starts out 35 foot wide and broadens out to the north to 70 feet at 300 to 400 feet and ends at 600 feet where a new bar is developing on the north side. At this point the stream meanders south so that the north riparian zone widens and the south bank is reduced to 25-30 feet by 900 feet. Between 700 and 800 feet on the north side the new gravel bar is small and the north side corridor widens out to 220 feet by 1100 feet that has been scoured of weeds for the time being Approximately two acres can be planted with tree seedlings depending upon sand deposits that will only become known once debris are removed. Parts of the now cliff like north bank may not be plantable until repaired and may erode more if March rains approach 1996 levels.

The native trees that border the vineyard are primarily valley oak, live oak, and California bay with minor scatterings of big leaf maple, buckeye, and Oregon ash. Alder is rare in the study area but prominent on the relatively undisturbed creek upstream where it appears a useful component of the stream side vegetation. Walnut and box elder are absent but should do well when planted. Exact decisions on quantity and species location will be made after a survey of this years flooding on the landscape surveyed last year. The ability to withstand the stream flows of the past three winters will supply useful information for the final planting design.